

## WHAT IS CLAIMED IS:

1. An energetic composite material comprising:
  - a plurality of inorganic particles selected from the group consisting of metals, metalloids, metal oxides, and metalloid oxides; and
  - 5 self-assembled monolayers formed on the inorganic particles, the self-assembled monolayers comprising multifunctional linking molecules and optionally non-linking molecules, the multifunctional linking molecules each comprising a respective linking backbone and respective first and second linking functional groups, the first and second linking functional groups chemically bonding to a corresponding pair of the inorganic particles so that the multifunctional linking molecules interconnect the inorganic particles to one another to form a network of inorganic particles interconnected by the multifunctional linking molecules, the optional non-linking molecules each comprising a respective non-linking backbone and a respective non-linking functional group, the non-linking functional group chemically bonding to a corresponding one of the inorganic particles, wherein a member selected from the multifunctional linking molecules and the optional non-linking molecules comprises a fluorine atom appended to the linking backbone and the non-linking backbone, respectively, to fluorinate the self-assembled monolayer.
  - 10 2. An energetic composite material according to claim 1, wherein the inorganic particles have an average diameter in a range of about 5 nm to about 3 microns.
  - 15 3. An energetic composite material according to claim 1, wherein the inorganic particles comprise a metal selected from the group consisting of magnesium, aluminum, boron, titanium, tungsten, and hafnium.

4. An energetic composite material according to claim 1, wherein the inorganic particles comprise a metal oxide selected from the group consisting of aluminum oxide, titanium oxide, molybdenum oxide, vanadium oxide, and iron oxide.

5. An energetic composite material according to claim 1, wherein the inorganic particles comprise oxygen passivated aluminum.

6. An energetic composite material according to claim 1, wherein the linking backbones each comprise a carbon atom.

7. An energetic composite material according to claim 1, wherein the linking backbones comprise a member selected from the group consisting of polyethers, hydrocarbons, and fluorocarbons.

8. An energetic composite material according to claim 1, wherein about 5 weight percent to about 100 weight percent of the self-assembled monolayers consists of the multifunctional linking molecules.

9. An energetic composite material according to claim 1, wherein the first and second linking functional groups are the same or different, and are selected from the group consisting of carboxylic acid, alcohol, thiol, aldehyde, and amide moieties.

10. An energetic composite material according to claim 1, wherein the first and second linking functional groups each consists of a respective carboxylic acid terminal moiety.

20 11. An energetic composite material according to claim 1, wherein the linking backbone has a plurality of fluorine atoms appended thereto.

12. An energetic composite material according to claim 1, wherein the linking backbone is perfluorinated.

13. An energetic composite material according to claim 1, wherein the multifunctional linking molecules comprise  $\text{HOOC}(\text{CF}_2)_n\text{COOH}$ , wherein n is in a range of 3 to about 20.

14. An energetic composite material according to claim 1, wherein the non-linking molecules constitute from about 1 weight percent to about 95 weight percent of the self-assembled monolayers.

15. An energetic composite material according to claim 14, wherein the non-linking backbone comprises a carbon atom.

16. An energetic composite material according to claim 15, wherein the non-linking backbone has a plurality of fluorine atoms appended thereto.

17. An energetic composite material according to claim 15, wherein the non-linking backbone is perfluorinated.

18. An energetic composite material according to claim 14, wherein the non-linking molecules comprise  $\text{CF}_3(\text{CF}_2)_n\text{COOH}$ , wherein n is in a range of 3 to about 20.

19. An energetic composite material according to claim 1, wherein a member selected from the group consisting of the multifunctional linking molecules and the non-linking molecules further comprises an energetic group.

20. An energetic composite material according to claim 19, wherein the energetic group comprises a member selected from the group consisting of a nitro, nitramine, nitrate ester, azide, and difluoro amino moiety.

21. An energetic composite material according to claim 1, wherein a member selected from the group consisting of the multifunctional linking molecules and the non-linking molecules comprises an ethylenically unsaturated crosslinkable group.

22. An energetic composite material according to claim 1, wherein the energetic composite material is castable, pressable, and/or sinterable.

23. An energetic composite material comprising:  
a plurality of aluminum particles substantially free of oxygen; and  
5 self-assembled monolayers formed on the aluminum particles to substantially passivate the aluminum particles against oxidation, the self-assembled monolayers comprising multifunctional linking molecules, the multifunctional linking molecules each comprising a respective backbone and respective first and second functional groups chemically bonded to a corresponding pair of the aluminum particles to interconnect the 10 aluminum particles, the multi-functional linking molecules forming a network of the aluminum particles interconnected by the multifunctional linking molecules.

24. An energetic composite material according to claim 23, wherein the aluminum particles have an average diameter in a range of about 5 nm to about 3 microns.

15 25. An energetic composite material according to claim 23, wherein the linking backbone comprises a carbon atom.

26. An energetic composite material according to claim 23, wherein the linking backbone comprises a member selected from the group consisting of polyethers, hydrocarbons, and fluorocarbons.

20 27. An energetic composite material according to claim 23, wherein about 5 weight percent to about 100 weight percent of the self-assembled monolayers consists of the multifunctional linking molecules.

28. An energetic composite material according to claim 23, wherein at least a portion of the multifunctional linking molecules are difunctional.

29. An energetic composite material according to claim 23, wherein the first and second functional groups are the same or different, and are selected from the group 5 consisting of carboxylic acid, alcohol, thiol, aldehyde, and amide moieties.

30. An energetic composite material according to claim 23, wherein the first and second function groups each consists of a respective carboxylic acid terminal moiety.

31. An energetic composite material according to claim 23, wherein the self-assembled monolayers further comprise non-linking molecules constituting from about 1 10 weight percent to about 95 weight percent of the self-assembled monolayers.

32. An energetic composite material according to claim 31, wherein a member selected from the group consisting of the multifunctional linking molecules and the non-linking molecules further comprises an energetic group.

33. An energetic composite material according to claim 32, wherein the 15 energetic group comprises a member selected from the group consisting of a nitro, nitramine, nitrate ester, azide, and difluoro amino moiety.

34. An energetic composite material according to claim 31, wherein a member selected from the group consisting of the multifunctional linking molecules and the non-linking molecules comprises an ethylenically unsaturated crosslinkable group.

20 35. An energetic composite material according to claim 23, wherein the energetic composite material is castable, pressable, and sinterable.

36. An energetic composite material comprising:

a plurality of aluminum particles substantially free of oxygen; and

self-assembled monolayers formed on the aluminum particles to substantially passivate the aluminum particles against oxidation, the self-assembled monolayers comprising multifunctional linking molecules and optionally non-linking molecules, the multifunctional linking molecules each comprising a respective linking backbone and 5 respective first and second linking functional groups, the first and second linking functional groups chemically bonding to a corresponding pair of the aluminum particles so that the multifunctional linking molecules interconnect the aluminum particles to one another to form a network of aluminum particles interconnected by the multifunctional linking molecules, the optional non-linking molecules each comprising a respective non-linking backbone and a non-linking functional group, the non-linking functional group 10 chemically bonding to a corresponding one of the aluminum particles, wherein a member selected from the multifunctional linking molecules and the optional non-linking molecules comprises a fluorine atom appended to the first and second carbon atoms, respectively, to fluorinate the self-assembled monolayer.

15 37. An energetic composite material according to claim 36, wherein the aluminum particles have an average diameter in a range of about 5 nm to about 3 microns.

38. An energetic composite material according to claim 36, wherein the linking backbone comprises a carbon atom.

20 39. An energetic composite material according to claim 36, wherein the linking backbone comprises a member selected from the group consisting of polyethers, hydrocarbons, and fluorocarbons.

40. An energetic composite material according to claim 36, wherein about 5 weight percent to about 100 weight percent of the self-assembled monolayers consists of the multifunctional linking molecules.

41. An energetic composite material according to claim 36, wherein at least a 5 portion of the multifunctional linking molecules are difunctional.

42. An energetic composite material according to claim 36, wherein the first and second linking functional groups are the same or different, and are selected from the group consisting of carboxylic acid, alcohol, thiol, aldehyde, and amide moieties.

43. An energetic composite material according to claim 36, wherein the first 10 and second linking functional groups each consists of a respective carboxylic acid terminal moiety.

44. An energetic composite material according to claim 36, wherein the linking backbone has a plurality of fluorine atoms appended thereto.

45. An energetic composite material according to claim 36, wherein the 15 linking backbone is perfluorinated.

46. An energetic composite material according to claim 36, wherein the multifunctional linking molecules comprise  $\text{HOOC}(\text{CF}_2)_n\text{COOH}$ , wherein n is in a range of 3 to about 20.

47. An energetic composite material according to claim 36, wherein the non- 20 linking molecules constitute from about 1 weight percent to about 95 weight percent of the self-assembled monolayers.

48. An energetic composite material according to claim 47, wherein the non-linking backbone comprises a carbon atom.

49. An energetic composite material according to claim 47, wherein the non-linking backbone has a plurality of fluorine atoms appended thereto.

50. An energetic composite material according to claim 47, wherein the non-linking backbone is perfluorinated.

5 51. An energetic composite material according to claim 36, wherein a member selected from the group consisting of the multifunctional linking molecules and the non-linking molecules further comprises an energetic group.

10 52. An energetic composite material according to claim 51, wherein the energetic group comprises a member selected from the group consisting of a nitro, nitramine, nitrate ester, azide, and difluoro amino moiety.

53. An energetic composite material according to claim 36, wherein the energetic composite material is castable, pressable, and/or sinterable.

15 54. A method for making the energetic composite material according to claim 1, comprising:

15 dispersing inorganic particles into a solvent, the inorganic particles comprising a member selected from the group consisting of metals, metalloids, metal oxides, and metalloid oxides;

20 dissolving multifunctional linking molecules and optionally non-linking molecules in the solvent, the multifunctional linking molecules each comprising a respective linking backbone and respective first and second linking functional groups, the optional non-linking molecules each comprising a respective non-linking backbone and a respective non-linking functional group; and

self-assembling a monolayer comprising the linking molecules and optionally the non-linking molecules onto the inorganic particles, said self-assembling comprising chemically bonding the first and second linking functional groups to a corresponding pair of the inorganic particles so that the multifunctional linking molecules interconnect the 5 inorganic particles to one another to form a network of inorganic particles interconnected by the multifunctional linking molecules, and optionally chemically bonding the non-linking functional group to a corresponding one of the inorganic particles, wherein a member selected from the multifunctional linking molecules and the optional non-linking molecules comprises a fluorine atom appended to the linking 10 backbone and the non-linking backbone, respectively, to fluorinate the self-assembled monolayer.

55. A method for making an energetic composite material according to claim

23, comprising:

dispersing a plurality of bare aluminum particles substantially free of oxygen in a 15 solvent; dissolving multifunctional linking molecules and optionally non-linking molecules in the solvent, the multifunctional linking molecules each comprising a respective linking backbone and respective first and second linking functional groups, the optional non-linking molecules each comprising a respective non-linking backbone and a 20 respective non-linking functional group; and

self-assembling a monolayer comprising the linking molecules and optionally the non-linking molecules onto the bare aluminum particles to substantially passivate the bare aluminum particles against oxidation and thereby form passivated aluminum

particles that are substantially free of oxygen, said self-assembling comprising chemically bonding the first and second linking functional groups to a corresponding pair of the bare aluminum particles so that the multi-functional linking molecules interconnect the passivated aluminum particles to one another to form a network of passivated 5 aluminum particles interconnected by the multifunctional linking molecules, and optionally chemically bonding the non-linking functional group to a corresponding one of the inorganic particles.

56. A method for making the energetic composite material according to claim 36, comprising:

10 dispersing a plurality of bare aluminum particles substantially free of oxygen in a solvent;

15 dissolving multifunctional linking molecules and optionally non-linking molecules in the solvent, the multifunctional linking molecules each comprising a respective linking backbone and respective first and second linking functional groups, the optional non-linking molecules each comprising a respective non-linking backbone and a respective non-linking functional group; and

20 self-assembling a monolayer comprising the linking molecules and optionally the non-linking molecules onto the bare aluminum particles to substantially passivate the bare aluminum particles against oxidation and thereby form passivated aluminum particles that are substantially free of oxygen, said self-assembling comprising chemically bonding the first and second linking functional groups to a corresponding pair of the bare aluminum particles so that the multi-functional linking molecules interconnect the passivated aluminum particles to one another to form a network of passivated

aluminum particles interconnected by the multifunctional linking molecules, and  
optionally chemically bonding the non-linking functional group to a corresponding one of  
the bare aluminum particles,

wherein a member selected from the multifunctional linking molecules and the  
5 optional non-linking molecules comprises a fluorine atom appended to the linking  
backbone and the non-linking backbone, respectively, to fluorinate the self-assembled  
monolayer.

57. An article of manufacture comprising an energetic composite material  
according to claim 1.

10 58. An article of manufacture according to claim 57, wherein the article is an  
ammunition casing.

59. An article of manufacture comprising an energetic composite material  
according to claim 23.

60. An article of manufacture according to claim 59, wherein the article is an  
15 ammunition casing.

61. An article of manufacture comprising an energetic composite material  
according to claim 36.

62. An article of manufacture according to claim 61, wherein the article is an  
ammunition casing.